KINGDOM OF BELGIUM

MINISTRY OF COMMUNICATIONS

POSTS TELEGRAPHS AND TELEPHONES

(62)

REPORT

OF THE INQUIRY RELATED TO THE ACCIDENT

OCCURRED TO AIRCRAFT OO-SJB

AT BERG

ON 15TH FEBRUARY 1961

SUPERINTENDENT OF STANDARDIZATION

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Commission d'enquête relative à
l'accident de l'avion Boeing
OO-SJB.

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Bruxelles, le 21 mars 1963.

Monsieur le Ministre des
COMMUNICATIONS,
17, rue de la Loi,
BRUXELLES.-

Monsieur le Ministre,

J'ai l'honneur de vous transmettre, ci-joint, le rapport d'enquête relatif à l'accident de l'avion Boeing OO-SJB de la SABENA, tel qu'il a été élaboré par la Commission que j'ai présidée.

Veuillez agréer, Monsieur le Ministre, l'assurance de ma haute considération.

P. NOTTET
Directeur Général,
Président de la Commission d'enquête.

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COMPOSITION DE LA COMMISSION D'ENQUETE.

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Président :

M. NOTTET, P., Ingénieur Civil.
Directeur Général de l'Administration
de l'Aéronautique.

Membres :

MM. DUCARME, J., Ingénieur Civil
Ingénieur en Chef - Directeur à l'Administration
de l'Aéronautique
Professeur à l'Université de Liège.

NEUVILLE, M., Ingénieur Civil
Directeur d'administration aux Services Généraux
du Ministère des Communications et des Postes,
Télégraphes et Téléphones.

TABURIAUX, F., Ingénieur Technicien
Inspecteur Technique ff. à l'Administration
de l'Aéronautique.

Conseillers :

MM. DILS, P., Pilote de ligne.

HUSSIN, R., Ingénieur Technicien

LEDENT, F., Pilote de ligne.

VAN LAER, J., Ingénieur Civil.

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NOTE

The attached text is a translation.

The official text of the report of the Commission is in the french language.

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AIRCRAFT ACCIDENT REPORT

SABENA BOEING 707-329 .. OO-SJB.. BERG BRUSSELS
FEBRUARY 15, 1961

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1. DATE & TIME OF THE ACCIDENT.

(All times in this report are GMT)

February 15, 1961 at 09.05, close to the Brussels National Airport, on the territory of the township of BERG.

2. RESUME.

At the end of a New York/Brussels flight, which is normal in every respect, the aircraft is on a long final to runway 20 of the Brussels National Airport and receives clearance to land. Instead of landing, the pilot, near the runway threshold, increases power and retracts the undercarriage. The aircraft gains some height and executes several circles in a left turn. During these evolutions the bank angle - while however decreasing several times for short periods - increases more and more until finally the aircraft is in a near vertical bank. The aircraft crashes and fire breaks out upon impact. The 11 crew members and 61 passengers are fatally injured. The aircraft is completely destroyed. One person on the ground is killed; another severely injured.

3. THE CREW.

3.1. Captain :
LAMBRECHTS, Louis, Marie, Antoine.
Born on 23.8.1917.
Domicile: 3, avenue d'Oppem - Wezembeek.
Holder of Airline Transport Pilot Licence n° 568/391,
valid till 30.7.1961.

The licence was endorsed for :
Boeing 707
Instrument flight
Night flight
Restricted Radiotelephone licence.
On 8.2.1961, the pilot had 15.383 h 50' of flight time.
Experience on Boeing 707
- simulator training : 6 h.
- flight training : 13 h 51' day
1 h 15' night.
- declared proficient on B.707 the 27.2.1960
- proficiency check 17.10.1960
- flying time on line : 840 h.

Rest periods : a) before the Brussels/New York flight from 9.2.1961 at 8 h.45' till 12.2.1961 - 15 h.30' or 78 h.45'

b) between the above flight and the return flight to Brussels : from 02 h.51' on 13.2.1961 till 01 h.30' on 15.2.1961 or 46 h.39'.

Last medical examination on 12.1.1961. Result satisfactory.

3.2. Co-captain
ROY, Jean, Eugène, Célestin.
Born on 17.10.1912.
Domicile: 452, boulevard Lambermont - Schaerbeek.
Holder of Airline Transport Licence n° 109/248,
valid till 5.4.1961.
The licence was endorsed for :
DC.6
DC.7
BOEING 707
Instrument flight
Night flying
Restricted Radiotelephone licence.
On 8.2.1961 the pilot had a total of 16.231 h.05' flight time
Experience on B.707 :
Simulator training : 6 hours.
Flight training : 14 h. day
0 h.45' night.
Declared proficient on B.707 on 21.3.1960.
Proficiency check on 31.10.1960.
Flying time on line : 686 hours.

Rest periods : a) before the Brussels/New York flight from 08 h.45' on 9.2.1961 till 15h.30' on 12.2.1961 or 78 h.45'

b) between the above flight and the return flight to Brussels from 02 h.51' on 13.2.1961 till 01 h.30' on 15.2.1961 or 46 h.39'.

Last medical examination on 21.9.1960
Result satisfactory.

3.3. Navigator :
KINT, Jean-Marie, François.
Born on 7.9.1924.
Domicile: 22, avenue Pénélope - Forest.
Holder of flight navigator's licence n° 1311/536,
valid until 4.11.1961 and a restricted radiotelephone licence.
On 10.2.1961 the navigator totalised 10.577 h.44' of flight time.

Rest periods : a) before the flight Brussels/New York from 17 h.30' on 10.2.1961 till 15h.30' on 12.2.1961 or 46 hours.

b) between the above flight and the return flight to Brussels, from 02 h.51' on 13.2.1961 till 01 h.30' on 15.2.1961 or 46 h.39'.

Last medical examination on 25.10.1960.
Result : satisfactory.

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3.4. Flight Engineer :
EDUWAERE, Lucien.
Born 16.4.1913.
Domicile : 73, rue Valduc - Auderghem.
Holder of flight engineers licence on B.707 n° 812/170, valid till 19.6.1961 and the flight radiolicence n° 812/170 valid till 19.6.1961.
On 6.2.1961 the flight engineer totalised 12.418 h.46' flight time.

Experience on B.707 :
- simulator training 26 h.
- flight training 154 h.03'
- declared proficient on B. 707 on 25.4.1960
- flight time on line : 603 h.

Rest periods a) before the flight Brussels/New York from 7.2.1961 till 15 h.30' on 12.2.1961 or more than 5 ½ days

b) between the above flight and the return flight to Brussels from 02h.51' on 13.2.1961 till 01 h.30' on 15.2.1961 or 46 h.39'.

Last medical examination on 1.9.1960.
Result: satisfactory.

3.5. Stewards :
DEMAEYER, Marcel.
Born 4.2.1932.
Domicile : 99, avenue H. Henneau - Zaventem.

DE VOS, Paul.
Born 16.12.1926.
Domicile : 6, avenue Orion - Woluwé-St-Lambert.

VANDEN BUSSCHE, Pierre.
Born 18.6.1918.
Domicile : 110, avenue Bloemendael - Stombeek-Bever.

VERNIMMEN, Henri.
Born 2.1.1926.
Domicile : 33, rue J. Vieux Jean - Molenbeek-St-Jean.

VOLEPPE, Robert.
Born 31.7.1933
Domicile : 9, rue Herreweghe - Jette.

3.6. Stewardesses :
ROMBAUT, Jacqueline.
Born 6.2.1935
Domicile : 85, rue Pierre Coecke - Alost.

TRULIEMANS, Jacqueline.
Born 12.10.1924.
Domicile : 2A, rue de Florence - Brussels.

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4. PASSENGERS.

The 61 passengers were fatally injured in the accident.

5. AIRCRAFT.

Boeing 707-329, serial number 17624, built in 1960 by the Boeing Airplane Company, at Renton - Washington - USA.
equiped with 4 turbojet engines Pratt & Whitney, type Turbo-Wasp JT 4 A - 9, registred OO-SJB.
Certificate of Registry n° 1289
delivered to Société Anonyme Belge d'Exploitation de la Navigation Aérienne (SABENA).
35, rue du Cardinal Mercier - Brussels.

Certificate of Airworthiness n° 1289 valid till 8.8.1961.
The certificate of airworthiness was revalidated on 9.2.1961 at the conclusion of a test flight where a delegate of the technical services of the "Administration de l'Aéronautique" participated.

All up weight at take-off in New York : 119.500 K of which
50.000 K of JP.I fuel.

Balance : 26% M.A.C.
Total estimated weight on arrival : 79.230 K according to the flight plan.

5.1. History of the Airframe :

At the moment of the accident, the airframe totalized 3.038 h. of flight time.
A type II overhaul had been carried out between 11.1.1961 and 9.2.1961.
Between this overhaul and the moment of the accident, the airframe had accumulated 37 hours of flight time.

5.2. History of the powerplants :

Engine #1	serial number 611345	
	operating time since last overhaul	458 h.
	total accumulated time of operation	1.649 h.
Engine #2	serial number 611248	
	operating time since last overhaul	37 h.
	total accumulated time of operation	1.430 h.
Engine #3	serial number 611715	
	total accumulated time of operation	717 h.
Engine #4	serial number 611783	
	total accumulated time of operation	263 h.

5.3. Trouble reports :

The trouble reports were examined.
It is found that the B. 707's of SABENA in general and OO-SJB in particular have been affected by blockings or hard spots in the aileroncontrol. The cases that appeared since OO-SJB was put into operation are joined in ANNEXE I.

An examination of the causes of these troubles, shows that they are the result of seizing, at low temperatures, in the aileron trim mechanism. The two trim-assemblies of OO-SJB, left and right, were removed and replaced during the overhaul that began on 11.1.1961. They were examined and tested by the Boeing Company. It has been possible to reproduce complete seizure of one of the mechanisms by coding to a low temperature. An important force, equivalent to 90 lbs at the wheel, was necessary to force the mechanism.

No other remark of importance were noted in the trouble reports of OO-SJB. To be complete let us note however two troubles wich affected the flightcontrols after overhaul.

The first one, noted by the pilot during the first testflight on 9.2.1961, indicated that : the trimbutton must be pushed harder than normal.

A second test flight was made to confirm the fault, after which the pilot notes "abnormal response of the stabiliser particulary after trimming, nose down, slight nose-up impulses give no result."

The corrective action, taken by maintenance, consisted of the replacement of the stabiliser trim motor. Trial on the ground gave normal responses in both directions.

The second incident was observed during the same flight, the pilot notes:

"At the beginning of the flight - strong tendancy of the aircraft
"to roll to the right - In level flight, the two leftwing spoilers
"are at the inch up.
"After descent, speed brakes out, at the moment of retraction there
"was a marked roll to the right - did not recur afterwards.
"At the end of the flight, the tendancy to roll to the right was
"considerably diminished".

An inspection on the ground did not reveal anything abnormal. This fault did not recur during subsequent flights.

The trouble report of the last Brussels/New York and New York/Brussels flight was found partly burried - it contained the following remarks :

".... switch lite "US."3	- replaced
".... brake handle not wired	- rewired
".... stand whate lite U.S.	- replaced
".... N up-lit switch not wired	
".... 37000 feet 1.5° - SMV	
".... Termittence à coup ds	
".... Channel (37.000 ft + 95.000 kg)	

".... nt, sextant 12° error.
".... heading selector sticks at certain points, frame of nose wheel
" ermergency door loose.

Signed Lambrechts.

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6. METEOROLOGICAL SITUATION.

6.1. General Atmospheric situation :

a) Vast anticyclone (max. 1035 mb) on the surface, centred over Hungary, but extending to our regions, France, Germany and Italy.

b) Weak southwesterly to southerly flow over Belgium. Sky practically clear.

c) Slight frontal activity over Wales and Britanny, practically stationnany.

6.2. On the descent path :

Reporting points	Flight level	Dry bulb temperature	Dew Point	Relative Humidity	Wind
Dover	380	- 59° C	?	?	230°/25 knts
Wulpen	280	- 45°	?	?	230°/20
Mackel	190	- 25°	- 35°	35%	240°/20
Dender	130	- 12°	- 23°	40%	250°/20
13 NM à l'WNW de l'aéroport (radar)	100	- 3°	- 17°	32%	260°/15
7 NM au NW (radar)	75	+ 1°	- 12°	38%	260°/10
	5000 ft QNH	+ 7°	- 4°	46%	270°/10
13 NM au N (radar)	3000 ft QNH	+ 8°			
Final Ry 20	1500 ft QFE maintaig-ning	+ 9°	+ 5°	76%	260°/10

6.3. At Brussels National Airport :

Visibility : 3.500 metres
Cloud : 7/8 at 8.000 metres
Wind : 190°/2 knots
Dry bulb temperature : + 7,4° C
Dew Point : + 4,6° C
Relative humidity : 82%

7. FLIGHT HISTORY.

7.1. Evolution of the flight until the end of radiocommunications.

The 15th of February 1961 at 02 h.06' the aircraft takes off from runway 22 right of the New York International Airport, destination Brussels. The Atlantic crossing is normal. The radiocommunications with the different interested control centers are normal.

At 08 h.36', the aircraft overflies Dover at flightlevel 380, then begins its descent to level 200 and contacts the Brussels control services, which communicate the meteorological conditions at Brussels.

Visibility	:	3 kilometers increasing
Ceiling	:	Traces at 6.000 meters
Wind	:	Calm
Q.N.H.	:	1028.4 millibars
Temperature	:	6.4° C

The aircraft overflies Wulpen at 08.43 h. at flightlevel 280 descending, then Mackel at 08.47 h. at flightlevel 190 descending.

At 08 h.48', the aircraft sends the following message on the company frequency "Estimating Brussels 08.54 - Aircraft technically O.K.". It then overflies Dender at flightlevel 130.
After Dender, radiocommunications between the aircraft and Brussels Approach Control (124.5 Mcs) were as followed :

08 h.50'55"
- Brussels Approach JB, we checked DU flight level 130 descending.
- Roger, JB, you (..?..) runway 20 for landing, the wind 330°/2 kt, if you wish I'll take you for final approach.
- Roger, thank you.
- What's your heading now ?
- Heading 10 ... (hésitation) 110.
- Roger, take the heading of 080 to the left.
- Roger, 080 JB.

08 h.51'35"
- JB, may start descend to 1.500 feet QFE 1024,5
- 1024,5, cleared to 1.500 feet.

08 h. 52'10"
- JB indentified 13 N.M. WNW., continue on your heading and also your descend.
- Roger, JB.
- JB, present level and rate of descend ?
- We have to reduce speed to make a quick descend, JB, we are now descending thousand feet a minute, we expect to go in south as soon.
- What's your present level ?
- 10.000 feet descending.
- In that case will you turn left on heading 020
- Roger 020
- You are coming too close to the antenna, I will loose sight of you on the radar.
- Roger.

08 h.53'40"
- Brussels JB, heading 020, flight level 7.500 now
- Roger, understand, your position is 7 miles N.W., continue present heading.
- Roger.

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08 h.55'40"
- JB, flight level ?
- 3.000 feet descending, still heading 020.
- OK, turn to the right on a heading 180.
- Roger, 180 to the right.
- Position is .... You are turning on long final, 13 miles North.
- Roger.

08 h.57'20"
- Brussels JB, heading 180, height 1500 feet.
- Roger, maintain 1500 feet and turn to the right on a heading of 190.
- Roger JB, 190 to the right.

08 h.59'30"
- Brussels JB, Hofstade 1500 feet.
- OK can you continue on contact with the ground ?
- OK Roger.
- You are cleared to land and call 118,6 from now on, you are 6 miles on final approach.
- All right, 118,6 - JB.

09 h.02'00"

The intonation of voice was normal and does not lead one to suppose that, until that moment, there was any particular worry on board, at least in the voice of the second pilot. However no call was received on frequency 118.6 Mcs which was operating normally. The aircraft was called several time on this frequency. The calls remained unanswered. Following this lack of contact, Brussels approach (124.5 Mcs) again called the aircraft several times until 09.04 giving it amongst other things clearance to land. These calls also remained unanswered.

7.2. Reconstitution of the trajectory.

7.2.1. Trajectory reconstructed according to ATC information and radiocommunications.
The map annexed in II shows this trajectory from the entry point into Belgian territory until the break in radiocommunications.

7.2.2. Trajectory reconstructed according to the testimony of witnesses (from the turn on to a long final approach until the impact).

The trace of this trajectory figures as A B C D I on the map annex III.

The trajectory thus determined and the description of the evolution result from the declarations of numerous witnesses including persons spaced along the trajectory, Air Force personnel stationed on the airport, personnel of the Air Traffic Control Services, aircrew and technical personnel

of Sabena. The foot of the arrow indicates in each case the location of the witness, whereas the point of the arrow shows the direction in which the aircraft was observed.

The witness located in B saw the undercarriage in the down position.

Point C is the last point at which the aircraft reported its position (Hofstade).

Until point D all witnesses saw the aircraft flying normally. It then starts its "overshoot". It overflies the runway threshold at an approximate height of 300 feet climbs whilst turning to the left along an apparently steep trajectory. Traces of smoke were observed coming from the four engines. At an estimated height of approximately 1500 feet it levels off reducing power. The aircraft described then, in azimuth, thrice 360°, relative to the approach direction. During this trajectory it started firstly a descent then several flight climbs followed by small descents; power was reapplied and out several times. The left bankangle - while considerably reduced during short periods increased more and more. The last 90° of turn were accomplished at slow speed, engines idle, with a large bankangle (close to 90° according to certain witnesses). The aircraft then turned nose earthwards and crashed. Fire broke out on impact.

7.2.3. Trajectory reconstructed according to the indications of the flightrecorder.

This trajectory figures as E, F & G on the map annex 3. This curve results from the analysis of the recorder tape. It is based upon information extracted every 15 or 12 seconds on the timescale of a graph of which a small scale reproduction is joined as annex 4 to the present report. The zero time point of this graph corresponds to the moment of impact. It is to be noted that the flight recorder was an experimental model and moreover it was found in an area where the fire was particularly intense. For this reason the value of the information furnished by the graph, annex 4 to the present report, during the last 4 or 5 minutes of flight is uncertain or worthless. The recorder does not give directly points of the trajectory. It provides at each instant the airspeed and heading of the aircraft. From these observations and supposing that the speed vecter has the same direction as the heading, we can trace a series of tangents of which the envelope constitutes the trajectory. What is more there is no correlation established between the times of the testimonies and the times of the recorder. However it is possible to try to superimpose the curve established according to the witnesses' testimony and the curve established according to the elements of the flight recorder by displacing the latter but on condition that its orientation which is determined by the indications of successive headings, is taken into account.
The result of this displacement shows that there is good concordance between the two trajectories. This permits us to localise the timescale and to situate point D at - 4 minutes relative to the impact time.

7.3. Special Observations.

Amongst the numerous witnesses who observed the last evolutions, only two appeared to have observed an object detach itself from the aircraft, but this at different times. A systematic search was initiated with the help of the state police and the army in the two zones determined according to the witnesses' indications. This search did not show any result (see § 9.1.).

8. FIREFIGHTING.

Immedialtely after the overshoot the aircraft manoeuvres appeared abnormal and the Air Traffic Control Services alerted the firefighting services of the "Régie des Voies Aériennes" the Air Force and "Brussels City". These services arrived quickly on the site.

9. EXAMINATION OF THE WRECKAGE.

The wreckage was minutely examined.

After examination on the spot the controls were wherever possible rebuilt. Those elements which could still function were given a functioned test before stripping. Low temperature tests were carried out on certain mechanisms in order to determine that they functionned correctly in extreme conditions.

The help of experts from the Civil Aeronautics Board, the Federal Aviation Agency and the Boeing Airplane Company was obtained for different phases of the technical investigatior.

9.1. Structure.

The aircraft structure was nearly completely destroyed by impact and the subsequent fire. A major part of the wings was burned, but is was possible to rebuilt the essential part of the controls. The aspect of the breaks revealed nothing abnormal and could always be explained by impact.

The debris found on the site of the accident justifies the conclusion that the aircraft structure was intact before impact. The cockpit debris projected outside the firezone presented no trace of fire.

The aspect of the breaks in the fuselage and the remains of the bagageholds showed no abnormality.

9.2. Controls.

9.2.1. Inboard Ailerons.

No indication on the surfaces, the structure, the hingsupports, the controltabs, the snubbers, nor on the balance panels permits to conclude to the existence of a fault prior to impact. The pressure seals on the passage of the controlcables into the fuselage have been found burned in their lodgings.

The examination of the markings observed on the structure permits to determine that at the moment of impact, the inboard ailerons were in a position for a right turn. The lefthand inboard aileron was in a 10° down position, while the righthand inboard aileron was in a 12° up position. The control pullies situated below the captain's controlcolumn, were found locked in position for a left-turn while those positioned below the copilot's control-column were found locked in position for a right turn. These pullies control the displacement of the aileron controltabs but not directly the ailerons. They are interconntected by a cable which was found broken; this explains the observed differences.

9.2.2. Aileron trim.

The positions of the aileron trim controldrums show that the aileron trim was in the neutral position on impact.

9.2.2.1. Lefthand trim mechanism.

The mechanism was found in a good condition. The axis supporting the retainers was found coated with grease. The trim actuator rod was found bent. The shearrivets situated on the follow-up linking the trimmechanism to the tabrod were sheared. The torque required to turn the follow-up with rivets sheared, was found to be 2,2 Kgm, which corresponds to a stickforce of approximately 5 kg.

The dimensions noted on retainers and the axis are as follows.

Measured diameters in inches		Minimum tolerance in inches
Retainers (threadside) (part 6-63222) Rear 1.2220 Front 1.2280	Axis (part 9-50128) 1.2176 - 1.2177	0.0043
Retainer (drumside) (part 6-63223) Rear 1.2222 - 1.2228 Front 1.2216 - 1.2218	1.2177 - 1.2179	0.0037

Dimensions initially foreseen by the maker

Retainer	1.2210	to	1.2230 in.
Axis	1.2160	to	1.2190 in.
Play	0.0020	to	0.0070 in.

Dimensions foreseen by Boeing Service Bulletin n° 1344 dated 27/7/1961

Retainer	1.2230 to 1.2260 in.
Axis	unchanged
Play	0.0040 to 0.0100 in.

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9.2.2.2. Righthand trim mechanism.

The mechanism was subjected to the fire.
The attachment from the drum to the wing was found broken.
The aileron trimmechanism was found locked in a position which could have precented aileronmouvement necessay for a rightturn.
This jamming was caused by the gripping of the springretainer of the mechanism.
Corrosion was found on the xtremity of the axis where the gripping occured.
The dimensions noted for the retainers and the axis were the follows :

Measured diameters in inches		Minimum tolerance in inches
Retainers (threadside) (part 6-63222) Rear 1.2210 - 1.2220 (1) Front 1.2210 - 1.2220	Axis (part 9-50128) 1.2188 - 1.2194 (2)	.0016
Retainers (drumside) (part 6-63223) Rear 1.2222 - 1.2244 Front 1.2218 - 1.2222	1.2185 - 1.2186	.0032

(1) At a certain place, the diameter decreases to 1.2192 in.

(2) There where corroded the diameter increases to 1.2200 in.

The Boeing Company analysed the corrosion agent and found an important proportion of sulfates. It estimated that due to the fire, the gazeous atmosphere resulting from the combustion of fuel - (which contains sulfur) - could be conducive to the formation of sulfates.

The shearrivets located on the follow-up driven by the mechanism were not steared.

9.2.3. Outboard ailerons.

No indication permitted to determine with certainty the position of the outboard ailerons on impact.
However the measurement of the extension of the controlrods of the lock-out mechanism showed that they must have functionned and that the ailerons should normally have been in the neutral position.

The controlsystem of the lefthand outboard aileron was found intact with the exception of the quadrant which was found broken. The quadrant is a casting which permits the control of the outboard ailerons through a cablelink with the inboard ailerons.

Apart from deformations due to impact, nothing abnormal was found amongst tho remaining parts of the structure the balance panels, and the hinges of the left aileron. The righthand aileron controlsystem was badly damaged. The aileron control rod was bent and the steel extremity was broken. Nothing abnormal was found amongst the remainder of the structure, the balance panels and the hinges of the right aileron apart from the deformations due to impact.

Note: It is to be noted that in ca of seizure of an outboard aileron :

a) flaps down : the inboard ailerons will also be blocked;

b) if flaps are retracted : the inboard aileron adjacent to the seized outboard aileron will be forced in the same direction as the position of the seized aileron until such moment that the inboard aileron reaches its stop. For example, the inboard aileron will be forced upwards if the outboard aileron is seized, in an "up" position and vice-versa.

When the inboard aileron reaches its stop the seizure of the outboard aileron has to give sufficiently or one of the parts in the mechanism will be deformed or broken. If the outboard aileron is seized up in the neutral position the inboard aileron will, after a momentary up displacement, return to neutral.

Tests were made in order to clarify the reasons for the fracture of the extremity of the outboard aileron controlrod under the possible action of flapretraction, ailerons seized in the down position.

These tests showed that the weakest part in the mechanism was the attachment bolt of the upper outboard part fixing the bell crank driven by the actuator breaks by stearing. The blocking torque of the aileron at the moment of rupture is of the order of 250 Kgm.
None of the 4 bolts, left and righthand, in OO-SJB were found sheared. It must therefore be presumed that the breaking of the aileron controlrod was due to the impact force.

9.2.4. Spoilers.

The position of the spoilers on impact is difficult to determine. The spoilers were all found retracted amongst the wreckage. However according to the marks found on the structure and rods it seems that the position on impact might have been as follows:

lefthand outboard spoiler : undetermined
lefthand inboard spoiler : probably retracted
righthand inboard spoiler ... : out (approx. 40°)
righthand outboard spoiler : undetermined.

The position of the spoilers could therefore correspond to a rightturn control demand.

The "speed brake" control lever was in the neutral position at the moment of impact.

There was no visible indication on whatever remained of the structure, controls, spoiler actuators and control valves that could lead to the conclusion of a failure prior to impact.

However, it must be noted that all shear-rivets situated on the control follow-up mechanism were sheared.

The 3 bypass valves of the system were found in the normal position (hydraulic pressure "on").

The bypass valves of the left and righthand outboard spoilers were contaminated by the fire. The inbound spoilers bypass valve was intact.

Bancktests of these valves (gladden PN 314040-1) gave the following results :

inboard valve : functioned normally
righthand outboard valve : functioned normally after reconditionning (replaced seals and springs).

lefthand outboard valve : functioned abnormally, even after reconditionning as hereabove. The valve remained stuck in the open position.

The overhead panel on which the controlswitches of the spoiler bypass valves are located was found considerable damaged by impact. The cover of the inboard spoiler bypass valve switch was found intact and in the normal (down) position but imprisoning part of the panel normally situated outside the switchcover. The cover of the outboard spoiler switch was found in the up position but with on its corners broken off.

9.2.5. Flaps.

The flaps were in the up position on impact. The selector lever was found on the 0° position.

Apart from multiple brakes due to the impactforce, nothing abnormal was found in the structure or control system. The stripping of the drive ball screw assembly showed nothing abnormal.

9.2.6. Rudder and Vertical Fin.

The vertical fin and rudder were not damaged by fire and found relatively intact. Traces on the structure show that there was a 20° rightrudder position on impact. The traces left on the quadrants controlled by the rudder pedals also show a 20° rightrudder position on impact.

No abnormality was found on the structure, hinges, balance panels, tabs or snubbers.

In particular the whole controlrodsystem was found correctly assembled and safety wired.

The test and subsequent stripping of the accessories of the rubberboostsystem showed no abnormality.

The trim was found with a one unit right setting.

The splitpins of the centering spring mechanism of the ruddertrim were found incorrectly installed. Also the cable which slakens on rightrudder application was found to be outside of its lodging. For large ruddermovements these wrongly installed splitpins will hit the central supportarm of the pullies of the ruddercentering mechanism. The corresponding cable will slacken when one of the pullies hits this arm and may jump out of its lodging on the drum. When the rudder returns to the neutral position or beyond this cable may then enroll in the neightbouring lodging. This will result in a displacement of the rudderneutral which, when measured on the ground, has been found to be of the order of 3°. This displacement of the neutral position will remain constant as long as the rudder is not displaced beyond the angle where splitpins will again hit the supportarm.

The pressure seals were found intact in their lodgings.

9.2.7. Elevator.

The elevator did not suffer damage fire and was found with relatively little damage.
No indication of failure prior to impact was found on the structure, hinges, balance panels, controltabs, stabilisor actuated tabs or snubbers.

Marks found on the balance panel housings show that the elevators were in the up position on impact.

The pressureseals were found undamaged in their lodgings.

9.2.8. Stabilisor.

The stabilisor was found in a position corresponding to 10 - 10.5 units nose-up trim close to the maximum of 11 units. This position was determined according to traces on the structure, the position of the controlscrew and the position of the cables on the rear and front drums.

The traces left by the index on the pedestal indicate a 8 - 8,5 units nose up trim but the cable connecting the frontdrum and the indicatingmechanism was found broken.

The stabilisorcontrol mechanism was examined for electrical and mechanical failure. The only significant descrepancies other than those resulting from impact and fire were :

a) A relatively important quantity of water condensation was found in the lower housing and in the input shaft well for the electric actuator.

b) The locking nut of the inputshaft of electrictrimactuator was found excessively tightened and the locking washer sheared.

c) A piece of fiber was found jammed between the rear drum and the cable. The cable had rubbed considerable on the protective cover.

Moreover, the testing of the electrical parts of the control, such as the thumbswitch on the captains control-column, the cut-outswitch, the power and safety relays and the limitswitches were examined stripped, and revealed nothing.

The cut-out switch on the pedestal seemed to be in the "ON" position. However the large distortion of the pedestal renders this indication somewhat uncertain.

Two half wheels and a handle of the manual trim wheels were found. The marks observed do not permit to ascertain with certainty if the handle was in the extended (indication of use of the manual trim) or stowed position.

Test were made (see annex 5) to determine the influence of certain faults found and to insure the correct operation of the trimmechanism taking into account the stabiliserposition. Low temperature tests indicate that water present in sufficient quantity in the input shaftwell of the electric actuator may cause the jamming of the electric trim motor control. I can also cause, while the motor continues turning, the excessive tightening of the locking nut.

Other low temperature tests were made to determine the influence of contamination possible in service on the operation of the mechanism.

This contamination is a result, on one part, of the humidity in the atmosphere which infiltrates during each flight when the mechanism is no longer airtight and on the other, of the grease on the screw which is sucked inside the topcasing during the movements of the screw. The contamination of the lower casing could result from the grease packed inside the mechanism's roller bearings.

What is the effect of such contamination ?
The screw is reversible and, when operating normally, this reversability is prevented by two brakes :

<u>One called primary brake</u> : contains "brake plates" contacting on one side the screwsshoulder and on the other a ratchetwheel whose movement in the direction of the braking is prevented by a pair of dogs. When the stabilisor is moved in a direction contrary to the load, the dogs retract and only the outside load must be overcome. When on the contrary, the nut tends to move due to the load applied, the screw will slip on the brake plates, the dogs will engage the rabelet and the torque will be the frictiontorque.

The second brake, called <u>secondary brake</u>, is a shoebrake, where, when the screw is driven, the shoes are in the released position and on the contrary, when the screw tends to move due to the effect of the load upon the stabilisor, the shoes are engaged.

The test were made so as to ascertain whether or not the brakes would slip due to contamination by humidity, ice or grease, or a combination thereof.

During those test the following was observed :

1) that the secondary brake may slip when it is contaminated by grease and in low temperature conditions or also during the period when regaining normal temperature following coldsoaking. Brakes which were not airtight ware removed from aircraft and have been made to slip. The sliprate was very high and in certain cases equal to double the rotation speed of the electricalmotor;

2) the efficiency of the primary brake, under the same conditions, was also reduced but not to the same extent. The friction coefficient fell well below the value for which there was slipping, but the slipping was only fractions of a turn of the screw and were more in the nature of creep-away.

If these tests established the possibility of slipping, they did however not reproduce conditions of prolonged slipping.

The fibre found between the rear drum and the cable wound upon it, due to the friction of this cable on the protective cover, could have caused the disconnect clutch to function and so make the electrical trim inoperative. The disconnect clutch mechanism operated with less than 42 lbs applied to the trimwheelhandle which is equivalent to a force of 193 lbs on the drum. The tests made at ambiant temperature, with the squashed fibre and a new assembly did not however provoke the operation of the disconnect clutch mechanism.

9.3. Engines.

The engines were dismantled and examined.

All damage can be attributed to impact.

The deformation suffered by the compressor and turbine blades shows that the engines were turning at the moment of impact shock but probably at reduced thrust.

The examination of the hot section did not show any anormalies. The bearing of all engines were exampt of faults except those caused by impact.

An important quantity of earth and foreign material was found in number three engine but was by all evidence scooped up on the ground. The thrust reversers were in the normal inflight position. The thrust reverser mechanisms of nº 1 & 4 engines were found intact.

The fuel controls were dismantled and examined. No anormaly was found.

9.4. Cockpit.

9.4.1. Engine instruments.

The following reading have been made.

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	Mot. 1	Mot. 2	Mot. 3	Mot. 4
PT 7 ing. Hg.	34.4	34.4	34.1	33.7
N1 %	-	49.9	34.0	-
TT 7 ° C	220	220	-	-
N2 %	-	-	-	-
FF	-	-	-	-
oil pression psi	39	42	54	48
oil temp. ° C	92	97	150	68
oil quantity U.S.G.	6.7	7.7	7.5	8.5

Two fuel flow totalisers have been found, one indicating a total consumption of 10.142 Kg, the other 10.073 Kg. The instantaneous fuel flow indicators were stuck at 700 Kg/h and 400 Kg/h.
Those different indications lead to the following commentary: The Pt 7 indications are relatively consistant and lead to the conclusion that, taking into account the existing atmospheric pression at airfiels level, the 4 engines were functionning at the time of impact.

Moreover, this indication is confirmed by the 220° C temperature readings (TT7) of engines ## 1 & 2. It can even be estimated that those engines were running at idle producing a thrust of about 1000 to 1500 lbs.

The divergent N 1 indications of ## 2 & 3 engines, respectively 49.9% & 34% do not contradict this conclusion if one takes into account the fact that one is in the range of low thrusts.

According to the gauges readings, the lubricating oil quantities still present in each engine tank are normal. The same can be said for the ## 1 & 2 engine oil pressures together with the ## 1 & 2 engine oil temperatures and even for engine ## 4.

About engine ## 3, there is a discrepancy : the oil pressure is considerable higher (54 psi) while the 150° C oil temperature is abnormal. No positive conclusion can be drawn apart that, most likely the real indication has been altered by the impact.

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9.4.2. Fuel Gauges.

The fuel gauges panel has been recuperated. The quantities read for the different tanks were :

left auxiliary	0
main 1	1.600 kg.
main 2	-------- (needle torn away)
main 3	2.000 kg
main 4	1.500 kg
right auxiliary	0
central	100 kg
Total	8.000 kg.

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It can be said that the fuel remaining onboard was adequate to feed the four engines.

9.4.3. Pedestal.

Engines controls.

The engines thrust levers were found in the respective following positions in relation to the pedestal lower limit stop :

mot. 1 - at 33 mm

mot. 2 - at 42 mm

mot. 3 - at 19 mm

mot. 4 - at 42 mm

The startlevers have been found in the notch corresponding to the idle position.

The ## 1, 2 & 3 engines reverse thrust levers were found in the forward and down position, corresponding to the normal position for flight. The ## 4 engine reverse thrust lever was broken.

Flying controls.

The pedestal central panel was deformed by the speed brakes control lever which left a trace located between the 0° and 10° speed brake position.

The flapslever was in the 0° notch.

The stabilizer trim cut-out switch seems in the ON position while the Mach Trim switch appears to be in the OFF position.

9.5. Electrical systems.

Several indications (auxiliary hydraulic pumps, instruments, anti-collision lights, autopilotssynchros, flight recorder, etc...) show that there was an electrical supply, as well AC as DC, on impact.

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9.6. Radio.

The VHF transceivers were found badly damaged but it was established that the frequency change onto 118.6 Mcs as asked by approach control was made.

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9.7. Autopilot.

The autopilotswitch "on, off, damper" was found in the OFF position.

The controlrod from the switch was found in its lodging.

The position of the aileronsynchro, found against its stop, indicate that the autopilot was disengaged on impact (as longas the A.P.is engaged the synchro remains in neutral).

The servomotors of the elevator and rudder were found in good condition and were in working order. Amongst others, the wiring of the electric motors was exempt of faults.

9.8. Mach Trim & K.I.F.I.S.

The mach-trim switch situated in the KIFIS system was found in good condition and in the "OFF" position on impact.
The mach-trim was disengaged and its adjustment was correct.
The speed on impact as determined by the KIFIS indications was 177 Kts.

9.9. Hydraulic System.

Nothing abnormal was found in the hydraulic system.

The hydraulic pumpmotors were recovered badly damaged but this was apparently not due to their operation.

The traces observed in the ventilators of the electricmotors driving the auxiliary pumps show that they were operating on impact. The pumps themselves were found in food condition.

9.10. Landing Gear.

The landing goar was retracted at the moment of the accident.

10. DISCUSSION OF THE DATA ESTABLISHED DURING THE INVESTIGATION.

The Boeing 707 OO-SJB was on a scheduled flight, non stop, from New York to Brussels. It results from the examination of the communications exchanged during this flight between the aircraft and the ground stations and also from the analysis of the flight recorder tape that no abnormal fact was found or reported until the moment when at 08 h.59'30" approach control gave the clearance to land at Brussels National Airport and requested that the tower be contacted on frequency 118.6 Mcs. OO-SJB replied : "All right 118.6 JB". At that moment the aircraft was at 1500 ft.altitude, near Hofstade, or at 5.5 NM from the threshold of runway 20 on which it was to land.

In fact, OO-SJB does not contact the tower, and after presenting itself close to the runway threshold at an altitude and in an attitude which seemed normal it begins a series of dissolute evolutions, witnessed by numerous persons, and crashed at 08.45', 2 KM north-east of the runway threshold.

At the time of the accident normal fuel consumption during flight taken into account and checked by the quantities which were indicated on the fuel gauges that were recovered, taking into account also the loadsheet on departure, it may be said that OO-SJB was at an ALL UP WEIGHT OF 77.500 K (176.000 LBS) with a trim of 25.5% M.A.C.

The flight recorder indicated at 08 h.59'30" a speed of approximately 220 knots, a magnetic reading of 185° and a pressure altitude of 1400 ft which, taking into account the local barometric pressure and the airport elevation, corresponds to an altitude of 1560 ft (QFE). Still according to flight recorder data analysis, we note from 0900 to 0901 a loss of altitude of 1000 ft/min. with a reduction in airspeed of 215 kts to 145.

To obtain this loss of altitude and speed reduction the pilot has probably taken the following actions in quick succession :

1. Power reduction
2. Select flaps to 30°
3. Select landing gear down
4. Select flaps to 40°
5. Select flaps to 50°.

If the aircraft was trimmed longitudinally at the beginning of this manoeuvering and if the pilot continued to maintain his longitudinal trim during the reduction in speed and altitude, the number of units of trim would have passed from one unit nose up to 5 units nose up; which represents approximately 8 seconds of trim motor action. The aircraft would therefore have been in the landing configuration and at a height of 560 feet above the airport elevation which would have made it possible to continue and land normally on the runway. Contrary to all expectations, the aircraft starts a manoeuvre which, in the beginning, ressembles an overshoot. This changes quasi immediately into a dissolute sequencie of evolutions, characterised by left hand banks and marked left turns. The detailed analysis of which was made in § 7.2.2.

The examination of the personal files of the crew members show them to have received a thorough indoctrination and training on this type of aircraft; that their qualifications and experience are well established. From the medical point of view, they had undergone the required examinations at the imposed intervals and the results had always been favourable; the minimum required statutory rest periods were observed and even exceeded, while the total flying times were within the limits authorised. On top of this a post-mortem examination of the crew members was performed on instruction of the public prosecutor in charge of the legal inquiry. No special observations were made known to the commission. Nothing therefore permits the latter to presume a reduction in the physical capabilities of the crew.

The aircraft had a certificate of airworthiness regularly delivered by the "Administration de l'Aéronautique" and valid till August 8, 1961. The aircraft was maintained by the technical services of Sabena and these operations are supervised by the control services of that company. The maintenance program is laid down by the technical services of the "Administration de l'Aéronautique" which, on top of this, approves the Sabena Controllers and makes its own supplementary independant checks.

The examination of the maintenance and work cards relative to aircraft OO-SJB did not show any abnormality.

The commission, in consequence, feels that OO-SJB was correctly maintained in accordance to the approved program.

On top of this, the examination of the "trouble reports" made for the flight in question, which was nearing its end and already signed by the captain and also the communication to the company at 08h. 48', establish clearly that the aircraft had behaved normally during the flight and was considered by the crew to be airworthy for a subsequent flight. The landing conditions (visibility, ceiling, wind) as stated in § 6, were good and had no influence on the accident. In other respects, no element permitted to retain the hypothesis of a criminal attempts or an agression on board.

Following the preceding, the investigations were necessary limited to a technical failure which only showed up clearly between the end of communications with the approach control and the beginning of the overshoot. This is a period of 1 min. 30 seconds. It is to be noted that it is during this period that the flight recorder registers a rapid decrease of speed and altitude which can only be explained if the crew took the actions, previously noted. These operations extend, in the present case, over a period of one minute.

As the evolutions observed thereafter show a clear impossibility to control the attitude of the aircraft, it is logical to look for the causes of the accident in a failure or combination of technical failures and to establish a correlation between the appearance of this or these failures with one of the manoeuvres made by the crew during the minute preceding these evolutions.

The engine thrust produces a certain effect on the attitude of the aircraft, determines the speed and is therefore closely related to the use of the flying controls. It is therefore necessary to examine which were the possibilities and the conditions of operation of the engines immediately prior to the accident.

The stripping of the engines did show no abnormal conditions and all four of them were running on impact. The reverser calm-shells were found in the normal in-flight conditions, which excludes the possibility of untimely reversing of one or more of the engines. The reverse thrust controls were found in the forward position. There was sufficient fuel on board as has already been established.

The engines were therefore able to operate and did operate. Indeed, it was possible to note certain engine indications on the instrument panel. These indications make it possible to determine that all 4 engines were idling and developed therefore from 1000 to 1500 lbs of thrust each.

Everything preceding permits the elimination of the engine operation as a factor intervening in the causes which prevented the maintaining of the attitude control of the aircraft. The examination of the possible causes of the accident is therefore limited to a flight controls failure.

Rudder.

The rudder was found practicaly intact and could be examined in detail.

The only defect found was that which was noted in the trim centering mechanism. The split pins locking the cables were installed wrongly and one of the cables was found outside its groove. The displaced cable was the one which slackens when right rudder is applied. This dislodging can only occur by a rapid or large movement of the rudder to the right. The failure could have originated in flight or on impact.

If it originated in flight, the force necessary at the rudder pedals to bring the rudder back to its real neutral position is moderate. Its only consequence could have been to increase the difficulty of identification of a control failure or its correction.

On the other hand, it does not seem possible to retain the hypothesis of the seizure or breaking of the rudder control. The break could only have existed in the two cables connecting the rudder pedal quadrants to the rear rudder quadrant. The seizure could only be the result of icing, of the balance panels or of the hydraulic rudderboost. The marks show that at impact the quadrant controlled by the rudder pedals and the quadrant connected to the rudder were in agreement and indicating right rudder. These marks probably indicate the rudder position during its final fall.

Let us recall that the rudder is equipped with a snubber which locks it in case of sudden and quick displacement. There was therefore probably no break as the marks on front and rear quadrant are in agreement and no seizure as the control surface pointed to the right, when all manoeuvres were to the left.

Taking into account the preceding, the Commission considers that a failure in the rudder or rudder control cannot be retained as a probable cause of the accident.

Elevator and Horizontal Stabilizer.

a) Elevator.

The elevator was recovered only slightly damaged and did not suffer from the fire. A detailed and complete examination was therefore possible.

The elevator control is composed of two independant mobile surfaces, left and right, each driven by a tab, which itself is controled by cables connected one from the left hand to the pilots control column and the other from the right hand to the co-pilots control column. Each of these surfaces has a second tab actuated by the stabiliser, the purpose of which is to bring the elevator back into alignment with the horizontal stabilizer.

The surface also has balance panels and snubbers.

It does not seem possible to retain the hypothesis of a break in the controls. According to the state of the debris, this break could have been localised only in the cables between the control columns and the rear bulkhead in the fuselage, which is very improbable.

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and Bornu), and its commercial capital, died on December 24. The four traditional electors chose his eldest son, Alhaji Mohammadu SANUSI, Ciroman Kano, as the new Emir. Mohammadu Sanusi was born in 1950, was educated privately, and first held office as district head of Bichi District in 1926, became a member of the Emir's Council in 1939, and in 1947 assumed charge of District Administration. He is said to have made a good record in the latter position, which covers 24 districts. The new Emir announced that he would make a number of reforms, with respect particularly to the local judiciary, land laws, and the organization of his personal household.

Comment: The impression which the reporting officer has gained from conversations with Administrative officers who have served in the North is that the new Emir will be considerably more progressive than his father, but still not as progressive a person as they would like to see heading this great principality, with a population of well over 5,000,000 people, and which still in many respects can be characterized as semi-feudal state.

From the human interest standpoint, the account of the installation of the new Emir, from the Lagos Daily Times of January 6, a clipping of which is enclosed (Enclosure No. 4), is well worth reading.

Governor's New Year's Broadcast

In his traditional New Year's broadcast to the country, the Governor (Sir John MACPHERSON) first touched briefly on international and Commonwealth affairs. With respect to international affairs, he said that the cold war continues and behind it the fear of real war, but that tension was less than a year ago and the threat of war has receded slightly, and pointed out how much it would mean to the world and their own people if the leaders of Russia and China were to show that they truly wanted peace and were going to stop interfering in the affairs of other countries. His brief remarks on Commonwealth affairs were largely addressed to the unity of the Commonwealth, as evidenced by the Christmas messages to the Queen.

With regard to Nigerian affairs, the Governor expressed the view that since the London Conference, the political atmosphere of the country had become clearer and healthier than it had been earlier in the year, when (as a result of the crisis at the end of March) the country had suffered a serious constitutional set-back. He felt that there had been a real quickening of political consciousness among the masses of the people, and they were weighing their governments of all levels and their leaders as never before.

The Governor

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The Governor made an eloquent plea for the end of squabbles and agitation by political leaders, outlining the basic things the ordinary people want, and which great progress could be obtained if energies were not dissipated in squabbles between political leaders - the maintenance of law and order; services without "dashes"; improved education and health facilities; good prices for produce; water supply and better communications; jobs with a fair day's work for a fair day's pay. He asked that the political leaders ponder these things before the re-convening of the Constitutional Conference on January 18, and that the people urge their leaders to support the course he had suggested.

Comment: It may be noted that the Governor and Lady Macpherson made an 18-day tour of the Eastern Region in November, visiting numerous small towns and rural centers, and were everywhere exceedingly well received. The things that the vast majority of the people want, and which the Governor has seen and knows at first-hand, were well outlined in his New Year's speech, as was his own sincere desire for an end to political bickering, and getting on with the job of economic, social and political progress. How far the political leaders can rise to the challenge is quite another question.

The text of the Governor's address will be found in the enclosed clipping from the West African Pilot of January 2, 1954.

Akintola to be Deputy Leader of Action Group

The press of January 16 reports that S. L. Akintola, Central Minister of Health, has been appointed by the Action Group to succeed the late Chief Bode Thomas as Deputy Leader of the party.

Comment: On the basis of Akintola's performance at the time of the crisis in the Central House of Representatives last Spring, he will not be a moderating influence or otherwise an improvement over Thomas.

Erwin P. Keeler.

Erwin P. Keeler
American Consul General

Enclosures:
1. Daily Times clipping of Dec. 17, 1953.
2. Daily Times clipping of Oct. 24, 1953.
3. Daily Times clipping of Nov. 12, 1953.
4. Daily Times clipping of Jan. 6, 1954.
5. West African Pilot clipping of Jan. , 1954.

Dept. please pouch copies to London, Accra, and Dakar.

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In anyway, control would remain possible by the other elevator panel and the horizontal stabilizer. This sort of failure would not explain the manoeuvres of the aircraft, nor the position of the stabilizer. Neither does the hypothesis of a seizure of the elevator control seem realistic. It again could only have been localised along the cables heretofore mentioned or could have been due to icing. Once again it would not explain the aircraft manoeuvres.

It therefore does not seem possible to retain failure of the elevator or elevator control as a probable cause of the accident.

b) Horizontal Stabilizer.

The horizontal stabilizer was found in a 10° nose up position. Normally the stabilizer is adjusted so as to annul stickforces. Its position therefore depends for a given weight and balance on the configuration of the aircraft, its speed and the engine thrust. The position of the stabilizer in the case of OO-SJB would therefore in the landing configuration, at the reference speed (V ref = 1,3 Vs, Vs = stallspeed) and with little thrust, have been 5,9 units nose up. In the same configuration, but engines at take-off thrust, the position should have been approximately 2,5 units nose up.

The values would be lower for higher speeds in level flight. On the contrary, for airspeeds lower than V ref., the position could well be in excess of 5.9 units nose up, as it depends on the lift coefficient and varies linearaly with the latter (the lift coefficient at Vs equals about 1.7 times the lift coefficient at 1.3 Vs). Thus the stabilizer position should be about 8 units nose up at 105 kts in level flight and landing configuration.

We can therefore conclude that the stabilizer position was abnormal for the approach.

Let us recall the presumption that does exist, that is to say the protective coverings of the spoiler by pass switches were lifted. This indication seems to mean that the pilot had wished to by-pass one of the two spoiler systems either to eliminate a defective spoiler system or to obtain a nose down pitch movement in order to compensate for the exagerated nose up stabiliser position.

The stabilizer position can only be explained if :

1° one of control systems of the stabilizer ran away;

2° there was an intimely slipping of the horizontal stabilizer due to non balanced aerodinamic loads, acting upon it, or

3° a failure of one of the other flight controls required an increased action of the stabilizer.

Let us examine these different suppositions :

<u>1st hypothesis</u> :

The position is the consequence of a failure in the control system of the stabilizer. The stabilizer can be controlled by the auto-pilot,

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by the mach-trim system and by the electric motor of the manual s[illegible].

The auto-pilot was disconnected on impact (position of synchroniser - aileron synchro, switch position on pedestal). The servo-motor was recovered completely destroyed but the mach-trim can be eliminated, the switch inside the KIFIS having been found intact and in the open position (it is normally open below 0.83 Mach). It is still possible to imagine a short circuit or a faulty toggle switch which could have caused a continuous displacement of the stabilizer, as only one toggle switch was found and moreover the electrical cabling in the pilot's control columns was badly damaged by fire.
This case is, however, foreseen in the emergency procedures and it suffices to operate the cut-out switch on the pedestal to cut off the electrical supply to the motor and the clutches. The switch and the relay were recovered damaged but nothing permits to think that they did not function perfectly before impact. What is more, it is difficult to believe that during the 8 to 10 seconds that the runaway would have lasted, the pilots did not have an opportunity to operate the cut-out switch. It seems that an incident on the toggle switches, cut-out switches and relais cannot be retained.

2nd hypothesis.

The position is the consequence of a slipping stabilizer.

The uncontroled slipping of the horizontal stabilizer under the influence of more balance aerodinamic loads which it could be made to endure is prevented by two friction brakes. Tests were made on these devices and are to be found in annex 5 to the present report. They would merit further consideration by an organisation that disposes of the required special installations. These tests have, however, shown that in certain conditions, which may be encountered in normal operations, one of these brakes slips at high speed and is therefore inefficient while the other brake slips out at a slow rate. There remains therefore some doubt as to the efficiency under all circumstancies of the braking device. Here would be a possible explanation of the accident, the more as, once the stabilizer out of trim, the aerodinamic loads which act upon it have an unfavourable influence which increases with the slip.

The Commission feels, however, that is difficult to admit this explanation because it would then have been necessary for :

1. the two brakes to become inoperative;
2. the slipping of the primary brake to be rapid, when the tests under conditions of severe contamination produced only slow kreep.

Finally, a rapid slipping due to aerodinamic loads would most probably have brought the screw nut in contact with the mechanical stop, whilst in actual fact it was found 1 to 2 turns away from this stop. One would therefore have to admit that the crew could have partly returned the stabilizer, but as already stated, no certain indication whatsoever of the use of the manual trim could be found.

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3rd hypothesis.

The position was necessary to compensate for the failure of one of the other flight controls.

It should be examined if this 10 units nose up position was not initiated by the crew during the manoeuvres which followed the overshoot in order to find a position of equilibrium.

The efficiency of the elevator decrease during turns. As a matter of fact, the pitching component of the angular rotation speed causes a relative air flow which tends to create a nose down movement and this due to distance between the stabilizer and the center of gravity.

Under those conditions, the nose up tendency of the stabilizer must be increased. A 10 units nose up could be necessary in order to be "in trim" for a coordinated turn at speeds between 120 and 155 kts (40° to 60° bank, flaps down).

The requirement is less in the flaps up configuration (the maximum lift coefficient is reduced). It should not be more than 7 units in a 60° bank turn at the buffetspeed. The effect of the elevator being equal to 5.5 units of trim it follows that, in the final configuration, the equilibrium of the aircraft was only possible within tight limits of speed and bank angle.

The Commission does not dispose of precise data for lower speeds, but the setting required to maintain a balance would probably be more important. If one admits a linear variation of the coefficient of aerodinamic pitching moment as a function of the lift coefficient, one finds a setting of the order of 10 units nose up.

In conclusion, it does not seem that the probable cause of the accident can be attributed to a malfunctioning of the stabilizer; it could have been used for a steeply banked turn close to stallspeed.

Lateral controls.

Inboard ailerons.

In cruise, i.e. flaps retracted, the outboard ailerons are inoperative and inboard ailerons only are used. There were numerous cases of inboard ailerons in flight jamming write-ups in the trouble reports. The wreckage examination has disclosed that the inboard ailerons were deflected in such a direction as to produce a right bank without being possible to determine if the position was such before the impact or caused by it.

The aileron trim-cartridge was also showing a point where jamming occured and precisely preventing a right bank. This point was due to corrosion combined with insufficient clearance.

The cartridge corrosion deposit analysis was conducted by Boeing and leads to the conclusion that the corrosion was due to the effect of the fire subsequent to the crash.

Due to the control geometry, there is no doubt that the presence of this point prevents all possibility of lateral control beyond that point. Or, this point was so located so as to permit a full throw to the left and only permitted a very limited displacement passed neutral towards a right bank. However, the Commission does not see in this deficiency a possible explanation of the accident. As a matter of fact, if you can imagine that the pilot, when he realises that he lacks lateral control displacement to the right, decides to overshoot and starts a turn to the left, you cannot understand why he did not maintain the wings level later on using whatever remaining lateral control capability assisted by rudder. Moreover, there are shear rivets on the connecting rod between the jammed aileron trim cartridge and the aileron tab control mechanism. Once these rivets sheared, the aileron control is free. Now, these rivets were found intact. The theoretical shear force to be applied is 105 lbs at a point on the wheel. A test made on the recovered part produced a shear force for the rivets of 152 lbs. Notwitstanding the 50% increase over the theoretical force, it seems that it was possible to apply such a force, especially when it was made by two pilots.

It seems therefore that this supposition cannot be retained.

Outboard ailerons.

If one supposes that these ailerons are blocked in a position close to neutral but not exactly in neutral, the extension of the flaps will create a temporary displacement of the control wheel, displacement which could pass unnoticed by the pilot or to which he attaches no importance. The entire aileron system, both inboard and outboard, will be blocked if flaps are lowered partially or fully under those conditions.

The cynematics of the system are such that, if the pilot then decides to raise the flaps, the inboard ailerons will be carried along in an opposite movement of an amplitude corresponding to several times the amount of offset from neutral of the outboard ailerons. This operation could set up large internal stresses within the control system, stresses which could have as a result permanent distortion or the breaking of the control elements.

However, the inboard ailerons can be freed if there was no permanent distortion during this manoeuver and if the flaps regained the full up position.

What has to be remembered of the linking mechanism between outboard and inboard ailerons and flaps, is that there exist several possibilities of setting up a hard over position on the inboard ailerons if the outboard ailerons were locked before a after flaps extension. This could be a possible explanation of the accident if we did not take into account the following objections :

1° To the best of the knowledge of the Commission, there has never been a case of seized outboard ailerons reported;

2° There is nothing in the examination of the debris that supports the hypothesis;

3° The inboard ailerons were found in a position for a right bank which, due to the presence of the snubbers, could only with difficulty be explained by impact forces.

Spoilers.

The examination of the spoilers and their control mechanism has shown that the shear rivets on the follow up mechanism between the spoilers and hydraulic valves were sheared on all 4 pairs of spoilers. What is more, the hydraulic by-pass valve of the left hand outboard spoilers was found deficient; it remained locked in the open position.

If the rivets on certain spoilers were sheared before impact (which could not be determined) it follows that, when these spoilers are operated, they could go to the full-up position. In case the lateral controls are operated, they can then remain completely down or go to the full up position, their position being dependant upon the friction existing in the system (control valve, follow up with sheared rivets, control rods).

As the friction between the axis and the differential of the sheared follow-up mechanism is modified during the relative displacement of the two parts a progressive loss of alignment of the follow up mechanism of the corresponding hydraulic valve can ensue; thus variations in the up position of the corresponding spoilers.

In the most unfavourable case, they will, however, not retain the up position for an opposite control wheel rotation exceeding ± 17 to 20°.

A pair of outside spoilers completely up causes a torque which will result in roll rate of 13°/sec at 150 kts.

The amount of inverse wheel required to annul this torque is far superior to 20° of oppositie control wheel movement. At the moment the amount of control wheel exceeds this value, the spoilers will collapse and the control wheel movement will produce a roll rate in the opposite direction, the valve of which will depend upon the configuration, but approximately 4°/sec (flaps up, with spoilers). Without spoilers, it would be of the order of 2°/sec.

The by-passing of the spoilers would normally be obtained by activating the corresponding spoiler by-pass switch.

The spoilers cannot be by-passed if the corresponding by-pass valve remains locked in the open position. As the left hand outboard spoilers by-pass valve was found deficient, it follows that, if the shear rivets on the follow-up mechanism of the corresponding spoilers were sheared, the pilot could not overcome the fault in the lateral control system by the action foreseen therefore.

In tho most unfavourable condition heretofore mentioned the pilot would be confronted with a condition where he would have to find a lateral equilibrium which had become unstable.

The only possible way out would consist in cutting out the hydraulic utility system, on condition that the origin of the fault could have been predetermined.

The Commission is of the opinion that such critical flight conditions would quickly lead to an accident.

11. INTERPRETATION OF THE INVESTIGATION RESULTS.

The examination of the wreckage has permitted to determine the position of the control surfaces at the moment of impact :

- Stabilizer : 10 to 10.5 units nose up
- Elevator : pointing up
- Rudder : pointed 20° right
- Ailerons : -inboard : set for a right turn
  -outboard: probably neutral
- Spoilers : lefthand outboard : undetermined
  lefthand inboard : probably retracted
  righthand inboard : extended (± 40°)
  righthand outboard: position undetermined
- Flaps : up.

The analysis of these observations has shown that the pilot must have had normal use of the elevator, rudder and aileron controls. But it was established that the aircraft, during its manoeuvering, made only lefthand turns with variable bank which would have gone up to 60°. Besides, without being able to affirm that the position in which these various controls were found correspond necessarily to their position in flight, it must be noted that they all concur to indicate an attempt to turn to the right or the quest for a bank to the right. At the same time, the elevator is pointing upwards when the stabilizer is already 10 - 10.5 units nose up. There is here a concurence which, without giving any certainity, constitutes a presumption to be retained.

It must be concluded that an important abnormality has, notwithstanding the use of the flying controls and engines, forced the aircraft irresistibly to the left and prevented the pilot from reestablishing level flight and manoeuvering with a view to a landing.

It follows, if one tries to establish a sequence of events compatible with the facts, that all factors which could influence the lateral stability must be examined. Nothing justifying the conclusion of an engine failure, it is necessary to recall the following observations concerning the spoilers : all shear rivets on the follow-up system are sheared. The lefthand outboard spoiler valve, during tests, remains several times in the open position.

The observations made as to the position concerning the safety covers over the spoiler by-pass switches permit us to say at least that the pilot envisaged their use, which is to be connected with the lateral control difficulties observed.

The use of these spoilers by pass witches is only justified in two instances :

1) abnormal functioning of the stabilizer
2) abnormal functioning of the spoilers.

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The observations made eliminating the mal-functioning of the stabilizer, we are made to suppose that the pilot wanted to correct a spoiler malfunction. This reasoning is made more valid by the fact that at that time other case of shear rivets on the spoiler follow-up system shearing were found. Shearing of these rivets results in abnormal and erratic behaviour of the spoilers. While it is proven that a spoiler, following its separation from its follow up system, may go to the full extended (60°) position even for a relatively small aileron control wheel movement (3 to 5°) it also proven :

1) that it is necessary, in case of the most unfavourable displacement of the spoiler control valve, to apply 17 to 20° of inverse wheel to retract the spoiler completely;

2) that it is impossible for the pilot to bring back to neutral simultaneously all lateral control surfaces and that therefore he is confronted with a lateral control system modified in such a way that it is impossible to find a control position where the roll movement is zero.

The foregoing admitted and if the pilot arrived at the conclusion that his difficulties were a result of the spoiler system the fact of by-passing them can only aggravate the situation, because in the present case the left hand outboard by-pass valve does not function.
The pilot will then be in a situation when the aircraft has lost all lateral stability. The use of rudder to remedy such a situation would result in violent dutch roll difficult to stop due to the abnormal functioning of the lateral control and also by the tending to drop of the nose. Let us add to this the possibility of a displaced neutral position of the rudder which could have occured precisely at this phase, creating thereby a supplementary difficulty for the pilot.

Considering the preceding, one can try to reconstitute the sequence of events which lead to the accident.

Referring to the recorder indications, we note that the approach seems normal till 09.00.30 h. At that moment the reading trace accuses a rapid variation of 15° to the left immediately followed by an equal variation to the right. Unfortunately the trace stops immediately after (09.01.00 h.).

It seems reasonable to suppose that these variations in reading coincided with the beginning of the difficulties of OO-SJB. This would explain the silence of the aircraft on frequency 118.6 mcs; the troubles experienced now preoccupying the crew have incited the co-pilot to abandon the communications which he should normally have exchanged.

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At 09.01.00, the aircraft not being aligned with the runway, the pilot starts his overshoot.

If we admit that the cause of the trouble is the shearing of the rivets in the follow-up system of the left hand outboard spoilers, we can say that the difficulties would go from bad to worse.

Confronted by a lateral control problem the pilot has only one possibility of intervention, that is to by-pass the spoilers. The use of the by-pass switches seems confirmed by the observation of their covers amongst the debris. Whatever their use, it could only aggravate the situation as the left hand outboard spoiler was faulty.
But we saw that under certain conditions this will result in a regime of severe lateral instability. If this was the situation in OO-SJB it is most probable that it led finally to the loss of the aircraft.

However, the Commission has to admit that the above account while very plausible and based on certain material elements and observations has not a character of certainity. It does, however, feel that it cannot exclude it.

The Commission does not possess any indication as to when the flaps were retracted nor as to the reasons which led the pilot to retract them completely. It notes that, in any way, the fact of having found the flaps and gear in the up position is without connection to the accident sequence as exposed heretofore; the lateral instability of the aircraft with the modulated extension of the spoilers being a fact whatever the configuration.

Two questions come then to mind :

1°) What actions could the pilot take to correct the erratic functioning of the spoilers ?
The only possibility being to suppress the hydraulic pressure in the hydraulic circuit activating the spoilers. In order to accomplish this, the pressure in the utility system can be chopped by activating the pump pressure control switches of the hydraulic pumps.

2°) Why did the crew not take this action?
The Commission is of the opinion that, if we admit the sequence of events as explained heretofore, it was impossible in the time available and under the circumstances in which the crew found itself to identify with certainty the failures with which it was confronted. What is more, it must be noted that it is nearly impossible to observe the spoilers from the cockpit, which in itself would render the identification of the cause more difficult.

12. CONCLUSIONS.

Having done all possible reasonable investigations, the Commission concludes that the cause of the accident must be looked for in the physical failure of the flying controls.

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However, while it was possible to advance certain hypothesis relative to these possible causes, it must remark that they generate certain objections and can therefore not be considerad as entirely satisfactory. Only the physical failure of two systems can lead to a complete explanation, but leaves the door open to an arbitrary choice because there is not sufficient evidence to corroborate it.

13. RECOMMENDATIONS.

With regard to modifications that the Commission would recommend, it notes that the following Service Bulletins send out by Boeing and by Sabena, satisfy the suggestions that it could have made :

N° 1117 Spoiler follow-up crank shear modification (18 January, 1961).

N° 1336 Outb. spoiler shut off valve consolidation (18 September, 1961).

N° 1344 Inboard aileron centering spring cartridge modification (27 July, 1961).

N° 1410 Control wheel stabilizer trim switch replacement (5 September, 1961).

N° 1484 Hydraulic system solenoid valve replacement spoiler system (15 December, 1961).

N° 1635 Stabilizer trim electrical limit revision (15 June, 1962).

N° 1680 Rudder control centering spring cable guard installation (25 May, 1962).

N° 114 Sabena Bulletin - Installation of a supplementary brake for stabilizer actuator (7 May, 1962).

Moreover, the introduction of a spoilers position indicator would facilitate the detection of any abnormality in their operation and would permit adequate corrective action to be taken.

THE PRESIDENT

P. Nottet

THE MEMBERS

J. Ducarme M. Neuville F. Taburiaux

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ANNEX I

SUMMARY OF CASES OF AILERON STIFFNESS ON CO-SJB DURING THE PERIOD 12.1.60 TO 14.2.61

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1° 11.5.60 - Captain Schreiden - Flight LEO/JOBOURG.

During descent at Jo'burg - 260 IAS - 10.000 ft - Damper "ON" - aileron very stiff, may be slightly more to the right, become normal after very pronounced stiffness.

- Ailerons checked on ground - normal - no stiffness noted.

2° 12.1.60 - Captain Libert - Flight LEO/E'VILLE.

During descent LEO/E'VILLE, the aileron servo remained engaged. Right ailerons did not function, after disconnecting A.P.

Note : These controls refunctionned after using the A.P. disconnect switch on the control wheel, noted that the A.P. switch on the control pedestal was not completely in the "OFF" position.

- Checked controls on ground and found "O.K.".

3° 29.6.60 - Captain OWEN - Flight LEO/JO'BURG.

Flight controls (descent) at 12.000 ft, right aileron control completely locked. At 8.000 ft becomes normal.

- Proceded with complete aileron check and control of cables : nothing abnormal found.

4° 29.6.60 - Captain SMITH - Flight LEO/BRUSSELS.

At 31.000 ft tied control wheel to the left O.K., to the right was locked for a short instant to free suddenly - Controls tested on ground : nothing abnormal noted.

5° 14.7.60 - Captain SMITH - Flight LEO-BRUSSELS.

During the descent to BRUSSELS, the aileron control is stiff in right turn only and without A.P. engaged.

- Checked controls on ground : O.K. suppose icing.

6° 10.8.60 - Captain JAUMOULLE - Flight LEO/BRUSSELS.

At 39.000 ft found aileron locked, right turn impossible. Freed itself at 2.000 ft after 2 to 3 minutes in warm air.

- Checked control action on ground - OK.

point under observation.

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7° 24.8.60 - Captain GIGOT - Flight JO'BURG/LEO.

Stiffening of aileron control during descent.

- Probably ice on ailerons during descent.

8° 17.9.60 - Captain JAUMOULLE - Flight BRUSSELS/JO'BURG.

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At F.L. 330, right aileron locked, freed after slight force on controlwheel. During descent to E'VILLE, the ailerons (left and right) are locked; freed by moderate force on wheel.

- Checked aileron system on ground : O.K.

- Greased system.

9° 2.11.60 - Captain SCHREIDEN - Flight JO'BURG/LEO & ROME/BRUSSELS.

Frozen ailerons did not move by wheel or trim - please check controls - after thawing, feeling looser than normal.

- Checked controls on ground - nothing abnormal noted.

10° 3/4.11.60 - Captain HENQUIN - Flight ATHENS/TEHERAN.

Ailerons and ailerontrim frozen during descent to ATHENS and TEHERAN.

- See point T.R. 9 S.V.P.

11° 4.11.60 - Captain HENQUIN - Flight BEYROUTH/ATHENS/BRUSSELS.

Aileron and aileron trim frozen during descent.

- Problem under study - to follow.

12° 9.11.60 - Captain JAUMOULLE - Flight LEO/JO'BURG.

After one hour of flight aileron trim locked (SAT - 55°C)

Aileron trim freed during descent (SAT - 10°C)

During descent, noted ailerons also locked; all normal with SAT + 10° C.

- To be followed.

13° 12.11.60 - Captain VERPOORTEN - Flight GENEVA/BRUSSELS.

Clear air T - 62° C Stiffening in the ailerons during turns to the right in climb. Same thing noted during descent to GENEVA after 33.000 ft in left turn till final approach speed 160 indicated (idem at BRUSSELS).

- To be followed.

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14° 13.11.60 - Captain JAUMOULLE - Flight LEO/BRUSSELS.

After 1 hour aileron trim blocked.

Ailerons very stiff, mainly in case of left turn.

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15° 17.11.60 - Flight NEW-YORK/BRUSSELS.

For information, during climb, the left aileron control remained temporary locked. Idem during descent.

- Under observation.

16° 24.11.60 - Captain DE KEYSER - Flight JO'BURG/LEO/ROME.

There seems to be hard spot in the aileron control, sometimes to the left sometimes to the right.

During test : O.K., seems to be due to icing.

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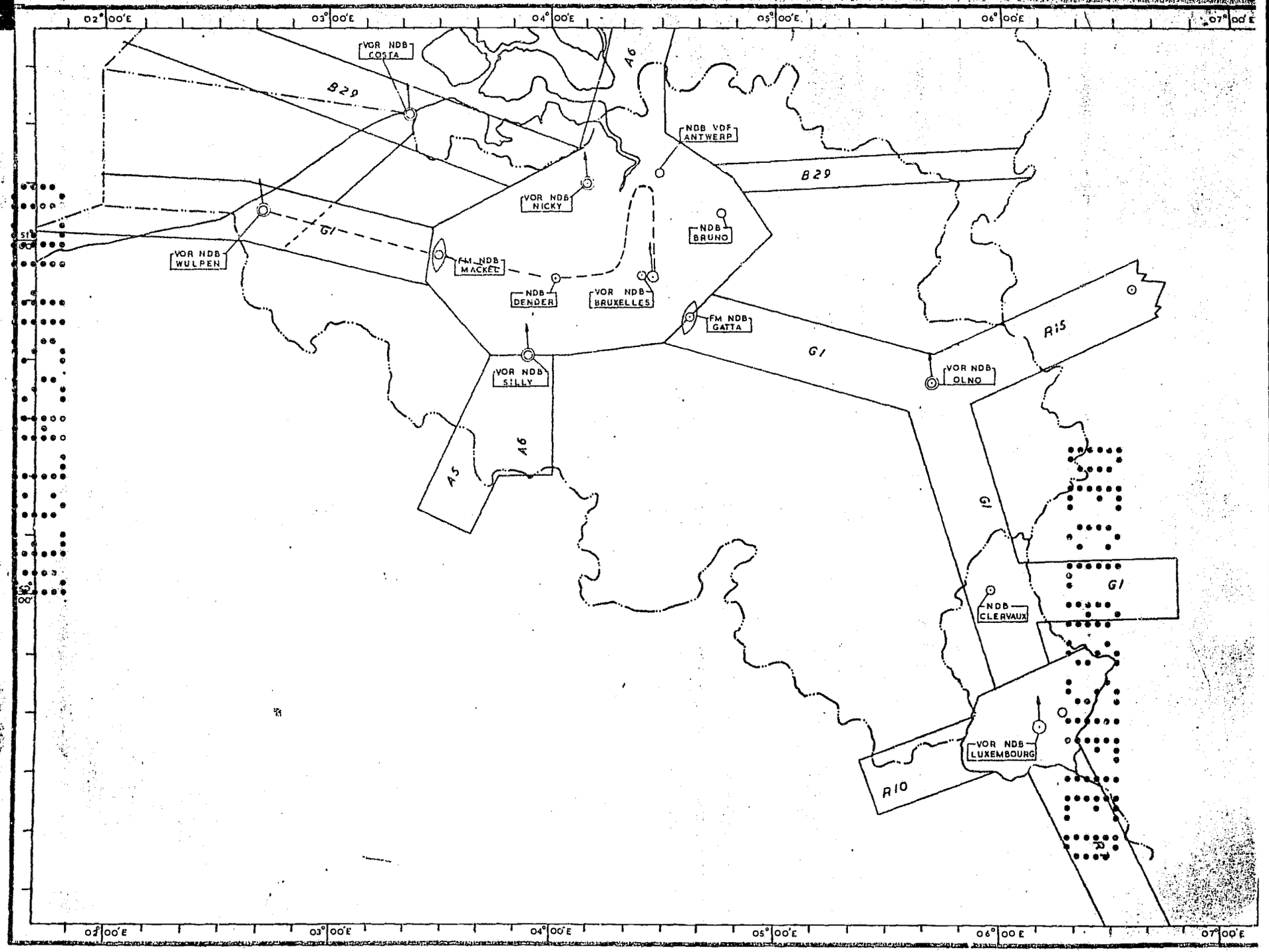
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VOR NDB NICKY
NDB BRUNO
VOR NDB WULPEN
FM NDB MACKEL
NDB DENDER
VOR NDB BRUXELLES
FM NDB GATTA
VOR NDB SILLY
VOR NDB OLNO
NDB CLERVAUX
VOR NDB LUXEMBOURG
B29
G1
A6
A5
R15
R10
R1

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The location of the mines has posed certain problems; they are about 30 miles from Cross River and about 75 miles from the nearest rail line; it has not yet been determined whether to evacuate the ore or to build a smelter nearby. Although building a railway would not be too difficult or costly over the 75 miles there is the added problem of the existing rail congestion between Enugu and Port Harcourt (the nearest sizable port) which would have to be solved.

Annual production of Nigeria's coal is about 600,000 tons; in 1948 it was 607,757 tons but in 1949 because of continued labor troubles which eventually erupted into riots production was considerably below schedule, total tonnage removed having been but 524,007 tons. The normal monthly target is 50,000 tons and that was attained only three times in 1949.

The coal of Nigeria is not of high quality but it is virtually the only coal deposits along the West Coast of Africa; the Nigerian railway normally consumes 365,000 tons a year and the rest is used for fuel in power plants and other industries except for a small tonnage sent to the Gold Coast and Sierra Leone for use in their railways. It is believed that could production be increased it could be exported to the Belgian Congo and neighboring French Colonies but only if the coal can be removed at an economic price. At the moment because of labor disturbances and lack of proper machinery it is almost economically preferable to import coal from Europe which is better in quality . The pit head cost of a ton of Nigerian coal is placed at 25 shillings which is judged exceptionally high.

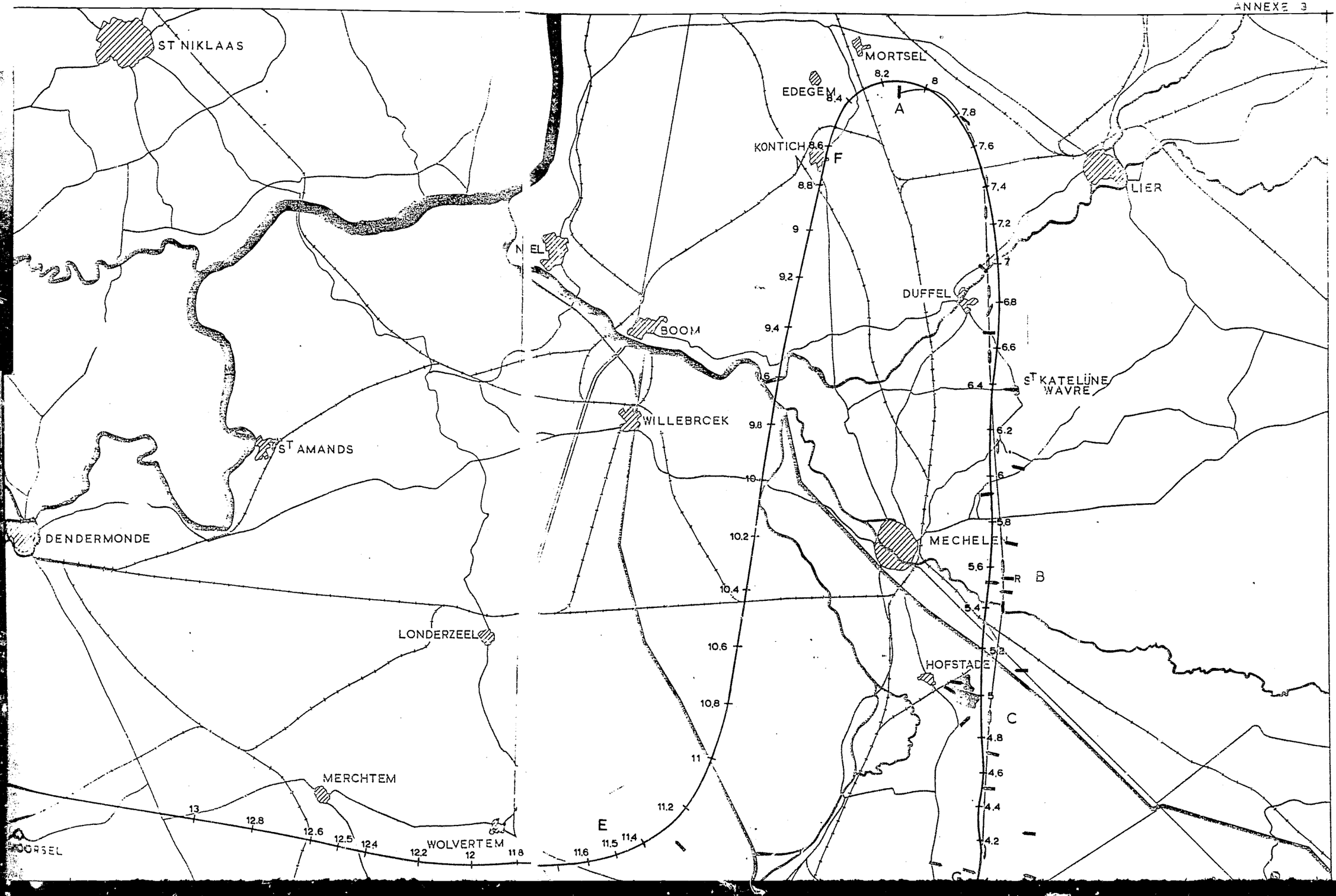
Reserves of the coal are believed quite ample; the Government recently estimated them at from 17,000,000 to 20,000,000 tons.

In an effort to improve both output and reduce costs the Enugu Coal Board was instituted in late 1949. It had held but one meeting prior to the occurrence of riots in the mines. There are plans to utilize more machinery and otherwise modernize production methods but this will require funds which are not at the moment available on the scale required.

There were 2,272 ounces of gold (880 per 1,000 parts) extracted in the first nine months of 1949 which indicates total production will be below the total output in 1948 which was 3,294 ounces. In 1948 only 42 ounces were exported and a similar figure appeared likely for 1949. This was because of the high demand in Nigeria for gold in the form of jewelry; the demand was so high that prices paid were generally somewhat higher than those prevailing in London.

On the basis of production in the first nine months it seemed likely that the normal two tons of tantalite and three

ANNEXE 3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LIER
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BOOM
WILLEBROEK
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MERCHTEM
WOLVERTEM
DENDERMONDE
ST AMANDS
LONDERZEEL

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(c) Forest Products

The sales of Nigerian logs and timber are one of the few relatively important exports not subject to control. During 1949 as in other years since the war the majority of exports went to the United Kingdom; small shipments went to Sweden and Switzerland and (Western) Germany resumed purchases for the first time in a decade. No complete statistics for the entire year are available but on the basis of figures for the first nine months of the year it seemed likely that exports would probably be 200,000 to 300,000 cubic feet in excess of the 4,064,392 cubic feet exported in 1948.

Prices remained relatively stable until the devaluation of the British West African pound; in January, 1949, mahogany logs were selling for about £12-10-0 a ton while in December they were selling for £14-0-0 a ton for good mahogany and for about £18-0-0 a ton for logs suitable for plywood use.

Only a very minor quantity of Nigerian timber went to the United States; the small Nigerian exporters have so far failed to redeem themselves in the American market. In an effort again to sell to the United States and also to maintain and improve the quality of exports the Government decided late in the year to institute a form of voluntary inspection over exports.

The scheme was fully in operation for but the last two months of the year and while it covered but a small percentage of the average monthly exports of 350,000 cubic feet it was believed that it would result in improvement of quality and a lessening of trade complaints from dissatisfied customers. The system is voluntary and may be used at the request of either the purchaser or exporter. The Government-issued certificate of inspection states that the timber appears to meet the specifications called for in the contract. Even though the inspection is superficial in nature it is hoped this gesture may go far toward halting the unfortunate practices of unscrupulous (and often simply inexperienced) exporters.

The United Africa Company plywood factory was in full operation for the first time in 1949 and work had progressed substantially on the installations for the new Sawmill.*

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* Both of these establishments are discussed in the section on Industrial Development.

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EDEGEM
KONTICH
LIER
BOOM
DUFFEL
WILLEBROEK
ST KATELIJNE WAVRE
ST AMANDS
DENDERMONDE
MECHELEN
LONDERZEEL
HOFSTADE
MERCHTEM
WOLVERTEM
ASSE
VILVOORDE
BERG
STEENOKKERZEEL
BRUXELLES NATIONAL
BRUSSEL NATIONAAL
DIEGEM
ZAVENTEM
NOSSEGEM
BRUXELLES
BRUSSEL

A B C D E F G I R

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0 1 2 3 4 5 KM.

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Research on antrycide and its effectiveness against the tsetse fly has led the Veterinary Department to feel that while the new drug is undoubtedly of considerable value some of the initial enthusiasm was possibly unwarranted. A new research laboratory, the West African Treponemiasis Research Center, located at Vom, Nigeria, has been in existence slightly over a year but is still very much in a formative stage. It is planned to center all treponemiasis research to be conducted in the four British West African colonies in this one center.

Experiments were also begun to cross the indigenous Fulani cattle with a breed imported from French Senegal which is immune to Treponemiasis. It is hoped that by cross-breeding this immunity can be transferred to the Fulani cattle. From a very tentative and preliminary experiment it was learned that of a dozen Fulani, a dozen Senegalese, and a dozen cross breds all of which were exposed to treponemiasis nine of the Fulani cattle were found to have a positive reaction to the disease and one died; of the Senegalese cattle all were immune, and of the cross breds, there were but three with positive reactions. The cross breds are a rather handsome lot, brown in color being a cross between the white Fulani and black Senegalese; they have almost no hump, in contrast to the Fulani..

The Veterinary Department continues to produce about 250,000 pounds of butter a year and about fifty tons of butter fat which is sold within the country.

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ANNEX 4.

DATE OF FLIGHT RECORDER SFIM A 261 - N° 205 EQUIPPING CO-SJB.

[redacted]

Altitude.

The Z curve diagram represents the altitude read on the recording.

The zero altitude corresponds to a barometric pressure of 1013.25 mbs.

The QFE at BRUSSELS National at the moment of the accident was 1024.5 mbs.

The curve was obtained by measuring the sensitive trace and hardtrace of the barographe.

A point marked ⊕ was read on the sensitive trace.

A point marked + was read on the hardtrace.

The scale for the sensitive altitude trace is 1 mm per 80 ft.

The scale for the hard altitude trace is 1 mm per 600 ft.

Between 4 and 3 minutes before impact the altitude indicated on the diagram is uncertain ans was read on the hardtrace.

Speed.

The V curve diagram indicated the indicated speed in Knots read of the recording.

According to recordings made before the accident it may be admitted that no corrections have to be made to these readings.

The speed curve has been obtained by means of the sensitive and hard traces given by the anemometric capsul.

A point marked ⊕ is read from the sensitive trace.

A point marked + is read from the hard trace.

The scale of the sensitive speed is variable but at about 150 kts, is approximately 1 mm per 5 knots. The scale of the hardtrace in the same area is of the order of 1 mm per 30 knots.

Between 4 and 2 minutes before impact the speed is uncertain and has been read from the curve thought to be the sensitive speed one.

Heading.

The θ° curve represents magnetic heading in degrees read from the recording.

It has been noted, according to measurements made before the accident, that a correction of + 7° should be made to the readings of the magnetic heading in order to obtain the true magnetic heading.

[redacted]

Between 5 and 4 minutes before impact the heading readings are uncertain.

Acceleration.

The obscuring of the film was too important to permit reading of the accelerometer trace.

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Time.

The timescale of the recording is 0.6 minutes per mm.

The graph has been established taking as time origin the impact time (09.05 h.).

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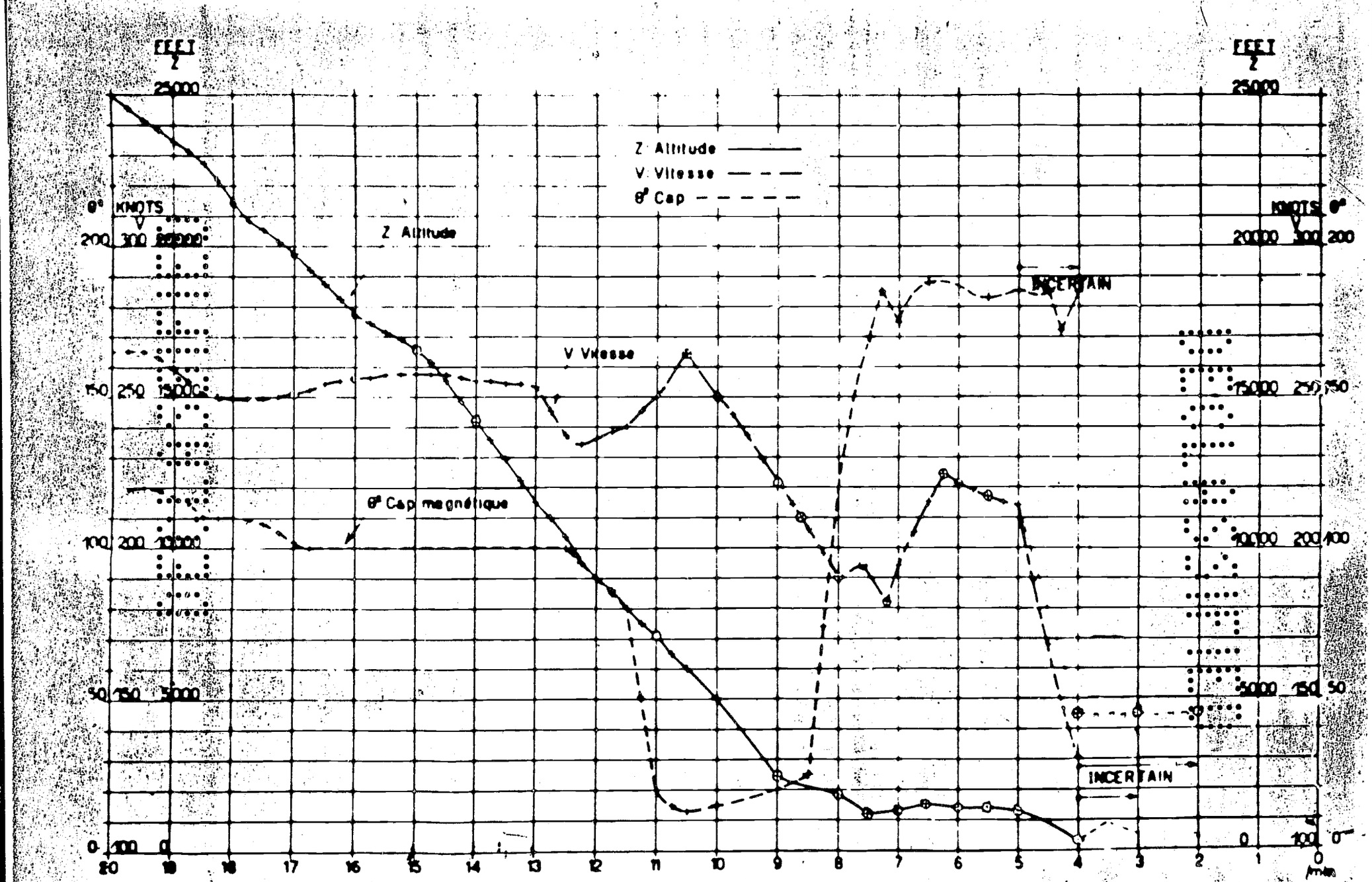
Z Altitude
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(g) Building and Construction.

No major Government or private buildings were completed in 1949 but many were started and continued. Three large general trading stores had grown so large that it became necessary to enlarge and remodel them into Department Stores. In addition several branches of existing stores were erected on the edge of the European residential area. The Government began its plan to center as many of its buildings as possible in one area by beginning construction of a new large structure to house the Posts and Telegraph Department.

Experienced, trained craftsmen are so rare and so expensive that more and more items are being imported than in the past. It was recently established that an ordinary door and frame made by local carpenters from Nigerian wood costs about £7 while an imported metal frame and door with glass insets will only cost £6; for the metal frame the maintenance is less and life longer since it is impervious to termites.

In general building supplies were ample for the first time since the war, with the occasional exception of some steel, and metal roofing. The introduction of aluminum as a roofing material proved very satisfactory and popular; it appeared to throw off more heat than tin roofs and its light-weight was also welcomed. Because so much of the materials must be imported houses are very expensive in Nigeria; small, two-bedroom residences are now costing from £5,000 to £7,000 to erect.

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ANNEX N° 5.

OO-SJB STABILIZER ACTUATOR TESTS AT BOEING - SEATTLE FROM II/27 TO III/2/1962

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TEST PROGRAM.

The test program as established a preliminary meeting between Boeing, the CAB, the SMV and Sabena, consists of two phases : the first one relating to tests performed using the OO-SJB primary brake plates and the second one using new brake plates in order to assess the effect of surface condition on plates friction coefficient.

Phase I - Tests using the OO-SJB brake plates.

A. Low temperature tests.

1. Two brakes operative
2. Secondary brake inoperative
3. Rime on both brakes
4. Secondary brake inoperative with rime on primary brake
5. Primary brake inoperative with rime on the secondary brake
6. Primary brake inoperative with grease on the secondary brake.

B. Ambiant temperature tests.

1. Primary brake inoperative with grease on the secondary brake
2. Primary brake inoperative
3. Both brakes inoperative
4. Secondary brake inoperative.

Phase II - Tests using new brake plates.

A. Ambiant temperature tests.

1. Secondary brake inoperative.

B. Low temperature tests.

1. Secondary brake inoperative and lower brake plate water soaked.
2. Secondary brake inoperative and primary brake contaminated with grease.

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C. Low temperature tests.

1. Secondary brake.
2. Secondary brake inoperative and primary brake contaminated with oil MIL-O-5606.

TESTS PROCEDURE.

The test program was not followed exactly, but was adjusted taking into account the results obtained.

On the other hand, the tests were interrupted prematurately; tests with the new brake plates were never carried out, Boeing being in the necessity of removing his qualified personnel.

The load was applied to the screw, in tension and compression, by 1.000 lbs increments.

For each condition, the maximum load applied was 10.000 lbs.

The system was actuated by a torque wrench or the manivel trim wheel.

The torques necessary to displace the screw in the direction of the force applied and in the opposite were measured.

The screw rotation speed was measured when the rate of slippage was low while the screw displacement speed was measured when it was high.

In other cases, the necessary force to set up the screw was measured.

Rime was deposited by blowing in the primary brake housing. The assembly was moved while rime was deposited.

TESTS RESULTS (OO-SJB BRAKE PLATES).

1. Low temperature test : - 65° F, without brake contamination, primary and secondary brakes operative :

Charges lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
500	10,4	8,3		
1000	15	10 - 12	11,2	17
2000	20	12	27	12
3000	22	15	32	15
4000	25	17	40	15
5000	30	22	42	22
6000	40	25	50	25
7000	50	27	55	27
			52	27
8000	55	30	65	30
			52	30
9000	60	32	62	35
			57	32
10000	67	35	62	32
			62	35
12000			75	42

2. Low temperature tests : - 65° F without contamination, primary and secondary brakes inoperative :

Charges lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
500	7,5	7,9		
1000	15	12	15	7
2000	16	12	22	10
3000	25	15	30	15
4000	35	20	35	17
5000	35	20	40	17
6000	37	25	43	22
7000	35	27	47	22
8000	42	35	50	25
9000	45	35	55	27
	47	35		
10000	55	37	57	28

A = with load
C = against load

NB. Measures made in ft. lbs on the automatic pilot servo.

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3. Low temperature test : - 65° F, secondary brake inoperative, primary brake contaminated by rime.

Remark : Rime deposit was made by the operator inhalation through the primary brake housing inlet, while the screw was under a tension of 1.000 lbs.

Charge lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
500	8	5		
1000	12	8	15	7
2000	15	10	27	12
3000	23	12	30	15
4000	25	15	35	17
5000	32	17	35	20
6000	35	20	37	20
7000	35	25	40	25
8000	38	25	40	25
9000	52	30	42	28
	48	27		
10000	50	30	50	27

4. Low temperature tests : - 65° F, both brakes operative with rime deposit on primary and secondary brakes.

Charges lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
500	5	5		
1000	11	6	10	7 - 10
2000	15	8	16 - 17	10
3000	16	12	22	13
4000	21	15	27 - 26	15 - 13
5000	22	17	30	18
6000	29	20	32	22
7000	32	23	35	19
8000	33 - 35	25	40	23
9000	33	27	45	26
	40	28		
10000	45	27 - 30	47	30

5. Ambiant temperature tests, secondary and primary brakes operative.

Remark : This test was made while the cold chamber was warming up, immediately after the outside rime deposit on the screw has melted.

Charge lbs	Tension		Compression	
	A	C	A ft.lb.	C ft.lb.
1000			5	7
2000			7	10
3000			7	10
4000			12	10
5000			18	13
6000			20	20
7000			23	25
8000			25	25
9000			27	25
10000			30	25
12000			37	32

6. Ambiant temperature tests, 2 brakes operative without contamination.

Charge lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
500	5	3		
1000	8	5	8	5
2000	12	8	16	6
3000	15	10	22	11
4000	16	12	25	13
5000	19	15	28	15
6000	20	18	31	17
7000	12 - 20	20	32	18
8000	30	23	34	21
9000	20 - 30	25	35	22
10000	25 - 35	29	36	26

7. Ambiant temperature, secondary brake inoperative, primary brake operative, without contamination.

Charge lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
500	4	3		
1000	10	5	10	5
2000	13	7	16	7
3000	15	9	20	10
4000	19	12	25	12
5000	19	14	29	15
6000	23	18	32	17
7000	26	20	35	20
8000	31	23	39	21
9000	33	25	43	25
10000	36	28	48	28

8. Low temperature tests : - 65° F, primary brake inoperative, secondary brake operative, without contamination.

Charge lbs	Tension		Compression	
	C ft.lb.	A ft.lb.	A ft.lb.	C ft.lb.
500	5	5		
1000	10	6	7	8
2000	12	7	10	10
3000	15	8	10	14
4000	17	10	13	16
5000	20	12	12	17
6000	23	12	13	20
7000	25	10	13	24
8000	25	16	14	26
9000	28	20	13	30
10000	32	19	13	30
	30	21		

9. Low temperature tests : - 65° F, primary brake inoperative, secondary brake contaminated by ice.

Charge lbs	Tension		Compression	
	C ft.lb.	A ft.lb.	A ft.lb.	C ft.lb.
500	4	6		
1000	6	10	5	8
2000	8	11	6	10
3000	12	13	8	13
4000	13	15	10	15
5000	15	14	13	15
6000	19	15	15	21
7000	22	14	15	25
8000	25	15	20	25
9000	28	14	20	27
10000	30	12	17	25
	30	17	14	27
	30	22	25	30
			16	30
			17	27
			10	

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10. Low temperature tests : - 65° F, primary brake inoperative, operative secondary brake contaminated by MIL-G-7118 grease.

Charge lbs	Compression	
	A ft. lb.	C ft.lb.
1000	5	3
2000		slips
3000		slips
4000		8 to 10 secs/turn
5000		13 secs/turn
6000		3 secs/turn
9000		high speed slippage followed by a blocage due to faulty winding of the drumcable.

N.B. Using the electric trim, the screw slips as soon as the electric motor is stopped.

11. Low temperature tests : - 65° F, primary brake inoperative, operative secondary brake contaminated by MIL-G-7118 grease.

Charge lbs	Tension		Compression	
	C ft. lb.	A ft. lb.	A ft. lb.	C ft. lb.
500	7	5		
1000	7	+ 3	4	5
2000	9	0 slips	- 0	10
3000	12	- 5	- 3	15
4000	13	- 7	0 + 2	17
5000	20 - 19	- 7 to 0	- 5	17
6000	22	- 12 to 0	- 5	20
7000	20	0	+ 6 to - 10	25
8000	25	- 12 25 to 0	+ 3 to - 10	25
9000	30	- 10 27 to 0	+ 6 to - 10	27
10000	35	- 10 32 to -15	+ 5 to - 12	35

N.B. The negative figures are the necessary torques to stop the screw.

12. Ambiant temperature tests, primary brake inoperative, operative secondary brake contaminated by MIL-G-7118 grease and lime deposit.

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Charge lbs.	Tension	
	A ft. lb.	C ft. lb.
500	3	3
1000	0 slips 1/3 of a turn	5
2000	0	7
3000	- 3	10
4000	- 5 slips 1/3 of a turn	12
5000	+ 3	15
6000	- 7 12 3/8 inches slippage in 8 secs.	20
7000	-13 10 $\frac{1}{2}$ " " " 7 "	20
8000	-13 10 $\frac{1}{2}$ " " " 7,5"	22
	Compression decrease to 3000 lb. at end of travel	
9000	-18 10 $\frac{1}{2}$ inches slippage in 7 secs.	42
10000	10	

Charge lbs	Compression	
	A ft.lb.	C ft.lb.
1000	5	0
2000	5 o.5. in. in 26 secs.	- 2
3000	8 6,125 in. in 10 secs.	- 4
4000	15 3,25 in. in 4,5 secs. (x)	- 7
(x) secondary brake rime has melted.		

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13. Low temperature tests : - 65° F, operative primary and secondary brakes contaminated by a weak emulsion of water and MIL-G-7118 grease.

Remark : The emulsion was produced by whipping a mixture of water and grease with a little stick, herefor the emulsion weakness.

Charge lbs	Tension		Compression		
	A ft.lb.	C ft.lb.	A ft.lb.		C ft.lb.
500	12	5			
1000	10	6		10	12
2000	25	15		10	10
3000	35	18		9	11
4000	36	23		8 - 10	15
5000	40	25	slips 3° in 10 secs.	6	20
6000	45	26		6	22
7000	47	32	slips 2° in 10 secs.	5	27
8000	43	33		5 - 10	25
9000	50	36		12	26
10000	45	37		10	32

14. Low temperature tests : - 65° F, secondary brake inoperative and operative primary brake contaminated by grease and rime.

Charge lbs	Tension		Compression		
	A ft.lb.	C ft.lb.	A ft.lb.		C ft.lb.
500	10	7			
1000	15	6		7	7
2000	15	7		7	8
3000	17	10	slips	7	12
4000	18	13	EOK	0	10
5000	15-18	15	EOK slips	0	12
6000	14	16	EOK slips	0	15
7000	20	20	EOK slips	- 4	22
8000	22	22	slips	- 5	22
9000	20	25		- 2	26
10000	20	26	slips	0	30

N.B. EOK means that low inputs to the electric control do not modify the light slippage.

15. Test at + 20° F, secondary brake inoperative, primary brake contaminated by MIL-G-7118 grease and rime deposit.

Charge lbs	Tension		Compression	
	A ft. lb.	C ft.lb.	A ft.lb.	C ft.lb.
5000	18	15	15	6

16. Ambiant temperature test at + 65° F, secondary brake inoperative, operative primary brake contaminated by MIL-G-7118 grease and rime deposit.

Remark : The primary brake casing temperature was + 20° F.

Charge lbs	Tension		Compression	
	A ft.lb.	C ft.lb.	A ft.lb.	C ft.lb.
1000	15	7	5	5
2000	15	12	6	8
3000	18	12	7	10
4000	18	15	8	13
5000	18	19	7	16
6000	22	15	7	16
7000	27	21	7	18
8000	30	20	(x) 12	25
9000	25	20	8	25
10000	30	20	(x) 18	25

(x) slips slowly.